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PHYTOTOXICOLOGY SURVEY REPORT

AMERICAN STANDARD - CAMBRIDGE, 1991

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PHYTOTOXICOLOGY SURVEY REPORT

AMERICAN STANDARD - CAMBRIDGE, 1991

Report prepared by:

George N. Vasiloff
Phytotoxicology Section
Standards Development Branch

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EXECUTIVE SUMMARY

Following a complaint investigation of severe vegetation damage in a City of Cambridge park in 1987, Phytotoxicology investigators concluded that boron, fluoride and other chemical emissions from the nearby American-Standard plant had caused the injury. A visual survey of vegetation at other sites around the plant revealed similar injury symptoms. It was noted that with increased distance from the factory, the severity and incidence of injury declined rapidly.

Based on the Phytotoxicology complaint results and the visual survey, American-Standard agreed to install a water bath abatement system in their spray booths in order to reduce emissions. By December, 1988 the water bath system was installed and operating.

Surveys repeated in 1989, 1990 and 1991 showed that concentrations of boron in vegetation were considerably above the Upper Limit of Normal (ULN) at most sites close to the factory. Similarly, concentrations of fluoride, barium, copper, nickel, and titanium were also elevated at sites close to the plant.

Moss bags were introduced in 1991 to monitor current emissions from American-Standard. Sharply-elevated or excessive concentrations of boron, barium, titanium, fluoride, sodium, nickel and copper were found in moss at sites close to the American-Standard factory. In spite of the abatement measures undertaken by the company in 1988, moss bag monitors and vegetation clearly indicate that the factory continues to be a source of spray-booth-related emissions.

1. Introduction/Background

A complaint of severe vegetation injury at a small City of Cambridge park was investigated in 1987 by the Phytotoxicology Section. The park is located directly across the Speed River from the American-Standard (AS) factory. Chemical analysis of the injured foliage showed excessive/elevated concentrations of boron and, in some cases, fluoride. Available boron (hot water-soluble) in 0-5 cm soil sampled at the park exceeded the 1 ug/g concentration considered to be phytotoxic. Because of the boron-like foliar injury and the high boron concentrations found in the foliar tissue, it was suspected that the nearby American-Standard plant was the source of boron and fluoride emissions. This suspicion was based on the knowledge that compounds containing boron, fluoride and other elements are used by the company during their coating and finishing processes.

As a result of the complaint investigation findings, Phytotoxicology investigators conducted a visual survey of other vegetation in the vicinity of AS in 1987. Boron and/or fluoride foliar injury symptoms were found at a number of locations close to the factory. The severity of the injury symptoms decreased with increasing distance from AS.

Based on the complaint investigation results and the visual survey, the Ministry's Cambridge office approached officials at AS to discuss factory emissions. As a result of these discussions, AS agreed to install a water bath abatement system on their spray booths that are used to apply an enamel cover coat. By December of 1988, the water bath system was installed and in operation. Subsequent to the installation, source tests within the stack were conducted. A report containing the test results was forwarded to the Ministry's Emission Technology & Regulation Development Section in Toronto for evaluation. Results of the stack tests were considered invalid due to unacceptable sampling methodology. The Ministry has requested that stack tests be repeated using approved methods.

In 1989, the Phytotoxicology Section initiated a formal vegetation and soil survey investigation around AS. Severe foliar injury, characteristic of that induced by boron, was observed on a variety of vegetation species at sites close to AS. The severity and incidence of injury declined sharply in all directions with increased distance from AS. Chemical analysis of tree foliage indicated that boron concentrations were above the Phytotoxicology Upper Limit of Normal (ULN) guideline at 11 of the 17 survey sites. In addition, concentrations of fluoride, barium, titanium, zinc, nickel and lead were elevated or excessive at sites close to AS.

Concentrations of available boron (hot water soluble) above 1 ug/g (considered to be phytotoxic) were found in 0-5 cm soil at 5 sites, and 2 sites in the 1989 survey soil collected from a depth of 25-30 cm. Excessive total boron concentrations were found in 0-5 cm soil at 8 survey sites. At sites close to AS, elevated or excessive concentrations of fluoride, titanium, zinc, copper, nickel and lead were present in 0-5 cm soil.

Severe boron-like injury was observed in 1990 on survey foliage at sites close to AS. Chemical analysis indicated that excessive concentrations of boron were present in the foliage at 8 close-in sites. Excessive levels of fluoride were found at 2 sites and elevated values of other elements were also detected at sites close to AS. Although an unknown percentage of foliar boron was absorbed from the contaminated soil, it was concluded that ambient emissions contributed to the foliar contamination, thereby questioning the efficiency of abatement systems installed in 1988.

In order to assess the efficiency of the abatement system at the plant, a moss bag monitoring system was used in the 1991 surveillance program.

2. 1991 Phytotoxicology Survey - Vegetation

The 1991 vegetation survey was conducted on 19 September 1991 at 26 sites in the vicinity of AS. Vegetation at all sites was examined for evidence of injury and sampled for chemical analysis. The increase in the number of sites (up from 21 in 1990) was intended to provide better survey coverage north and northwest of AS (Sites 28 and 24) and 2 additional control sites (26 and 27) to the north and southeast, respectively. The locations of all sites (except 22) are shown in Figure 1. Site 22, one of the survey control sites, is located in a city park, near the intersection of Water St. and Parkhill Road in Cambridge.

At most sites, either silver maple, Norway maple or both were utilized for observational and sampling purposes. At Sites 1, 16 and 22, neither of the two preferred species were available, and therefore, amur maple was substituted. At Sites 17 and 26, only Manitoba maple was available. Foliage at each site was examined for air pollution injury symptoms, and the observations were recorded. Injury severity ratings (percent of leaf area injured) and the percentage of all foliage injured at each site were the main parameters assessed.

Following the observational phase of the survey, foliage was collected in duplicate for chemical analysis. At each site, foliage was collected from the aspect of the sample tree(s) facing AS. At sites where severe foliar injury was encountered, samples of leaves that displayed typical injury symptoms were collected for retention in the Phytotoxicology herbarium.

The foliage samples were submitted to the Phytotoxicology laboratory to be processed unwashed, according to standard protocols. Processed samples were submitted to the Ministry's Inorganic Trace Contaminants laboratory for boron, fluoride, barium, titanium, sodium, nickel, zinc, lead, magnesium, copper, sulphur and iron analysis.

2.1 Visual Observations

Table 1 is a summary of the 1991 vegetation injury symptoms induced by industrial air pollutants. Injury to vegetation was most severe and extensive at sites close to AS (Sites 1, 2, 3, 5, 6, 8, 12 and 16). Figure 1 shows the close proximity of these sites to the factory. The severe injury noted at Sites 1, 2 and 3, suggest the influence of prevailing southwest winds.

The air pollution injury was observed on the terminal, marginal and intercostal areas of most survey tree foliage. The injury symptoms were characteristic of boron and, to a lesser extent, fluoride toxicity. Injury severity and the percentage of foliage affected declined with increased distance in all directions (with the exception of the northeast) from AS.

3. Vegetation Chemical Analysis Results

Concentrations of 13 elements detected in foliage sampled at all vegetation survey sites are shown in Tables 2-14. The data are averages for duplicate samples. Concentrations that exceed their respective Phytotoxicology Upper Limit of Normal (ULN) guideline are shaded. The rationale behind the method for determining ULN guidelines appears in the attached appendix. Also included in the tables are the 1989, 1990 and 1991 mean concentrations computed from 7 sites (1,5,8,10,12,16 and 17) situated close to and around AS. Mean annual concentrations from these 7 sites were compared in order to determine if environmental quality (as indicated by foliar chemistry) has improved significantly in the 3 year post-abatement period from 1989 to 1991. Based on past injury severity and chemical analysis results, Sites 1 and 16 are particularly important indicators of emissions impact and therefore should reflect abatement effectiveness.

Boron concentrations detected in the 1989, 1990 and 1991 foliage are summarized in Table 2. In 1991, foliar boron concentrations exceeded the ULN guideline at 12 survey sites, with the highest concentrations occurring at Site 12 (1045 ug/g). This represents a nominal increase from 905 ug/g in 1989 (but not reported in the 1989 or 1990 reports). At Site 16, boron concentrations were 1300 ug/g in 1989, 1050 ug/g in 1990, and 1000 ug/g in 1991. In spite of the abatement measures taken at AS, 1991 boron concentrations were higher than 1990 in vegetation at all but three sites and higher than in 1989 at 9 sites.

Mean concentrations of the 7 common sites (1,5,8,10,12,16 and 17) closest to the plant declined only marginally from 1989 to 1991. Boron in the collective foliage dropped from a mean of 704 ug/g to 481 ug/g in 1990. However, from 1990 to 1991, the mean increased to 659 ug/g.

The reasons for higher boron concentrations in 1991 relative to 1990 may be twofold. First, plants may be reflecting historical boron contamination in the soil. Soils collected in 1989 clearly indicated that sites close to AS contained elevated or excessive concentrations of available boron. Plant roots are able to absorb the available boron which is then translocated to the foliage and subsequently detected during analysis. Although this absorption mechanism is known to take place with boron, other elements may not be as readily available. Secondly, the water bath abatement system installed to prevent emissions may not be totally effective. Based on vegetation analysis alone, however, it is difficult to differentiate between current ambient boron emissions from AS and boron absorbed by vegetation from historically-contaminated soil.

In 1989, fluoride concentrations above the ULN were detected in foliage at Sites 1, 8 and 12, and elevated concentrations of the element were found at Sites 5 and 16. In the 1990 foliage, excessive, but lower, concentrations were still present at Sites 1 and 8. At Sites 5 and 16, fluoride values had also declined. Excessive levels of foliar fluoride persisted at Sites 1,8 and 12 in 1991 (Table 3). The extent of fluoride decline in foliage from 1989 to 1990 was reflected in the mean concentration of the 7 closest sites (60 ug/g vs 25 ug/g, respectively). However, between 1990 and 1991, the mean increased to 39 ug/g. Since the residency time of fluoride in soil is not as long as that for boron, nor is it as available to the plants, the elevated fluoride concentrations in the 1991 foliage is likely a reflection of current emissions from AS. In all three years, there was a clear gradient of foliar fluoride concentrations relative to AS.

Relatively high concentrations of barium were present in the 1989 foliage at Sites 1 (48 ug/g), 12 (47 ug/g) and 16 (33 ug/g). In 1990, the barium concentration at Site 1 had increased to 58 ug/g. By 1991, the barium concentration at Site 1 had dropped to 50 ug/g, but it was still marginally higher than the 48 ug/g of 1989. Similarly, 1991 barium values at Sites 2,5,9,10 and 11 all slightly exceeded those of 1989. The slight increase in barium concentrations between 1989 and 1991 is also apparent in the mean values of the 7 closest sites. Mean concentrations in 1989 and 1990 were identical at 27 ug/g. In 1991, the mean of the 7 sites had risen slightly to 30 ug/g (Table 4). Once again, in all three years, there was a clear gradient of foliar barium concentrations relative to AS.

In 1989, the nickel concentration in foliage at Site 16 (9 ug/g) exceeded the ULN guideline of 7 ug/g. By 1990, the value had dropped to 4 ug/g and then to 3 ug/g by 1991. At Site 1, an opposite trend is apparent. The nickel value increased from 6 ug/g in 1989 to 7 ug/g in 1990 and then to 9 ug/g in 1991. Although the mean value of the 7 close-in sites dropped to 3 ug/g in 1991 from 4 ug/g in 1989, the decrease is almost exclusively attributed to the sharp decline observed at Site 16 (Table 5). The nickel concentration gradient is much less pronounced than either boron or fluoride, as elevated levels occurred only at the sites immediately adjacent to AS.

There was a very weak concentration gradient relative to AS for titanium, zinc, copper, and iron in tree foliage. Of these four elements, only zinc concentrations were (marginally) consistently lower in 1991 relative to the two previous sample years. There were no consistent concentration gradients for lead, magnesium, aluminum, and sulphur in tree foliage, and concentrations varied insignificantly between sample years.

Foliage collected in 1989 was not analyzed for sodium. Mean data available from 1990 and 1991 show that the sodium content in foliage increased from 39 ug/g to 51 ug/g (Table 14). At individual sites, sharp increases were noted at Sites 1, 5, 13 and 15, whereas declines during the same period were noted at Sites 8, 19 and 21. Because the highest 1991 sodium values occurred at sites clustered close to AS, it is concluded that the factory continues to be a current source of this element.

4. 1991 Moss Bag Surveillance Program

Moss bags have been used extensively by the Phytotoxicology Section and other similar agencies to monitor current atmospheric emissions from a variety of industrial sources. Moss bags provide a relatively inexpensive air monitoring capability and are particulary useful in areas where vegetation is not present. Around AS, moss bags were used in conjunction with vegetation and soils to differentiate between historical contamination effects and current emissions.

Some chemical elements contaminate soils, and their presence and effects may persist for many years. Vegetation situated in the contaminated soil may absorb some of the elements through their root systems and translocate them to the foliage. Depending on the elements, accumulations in the foliage may result in foliar injury. Even though current ambient air pollution concentrations are low, injury to vegetation may continue for a number of years due to the absorption and translocation process from contaminated soil. Moss bags, however, have no connection to the soil and, therefore, they are not affected by historical soil contamination, but rather, they monitor only current ambient conditions.

Moss bags used by the Phytotoxicology Section consist of three grams (± 0.1 gram) of laboratory-washed and selected Sphagnum moss fibres contained within a polypropylene screen pouch measuring approximately 15.5 cm x 6.5 cm, which provides a moss surface area of about 100 cm^2.

In 1991, moss bags were introduced to the AS survey to provide an indication of current emissions, a differentiation not possible with vegetation and soil because of the historical boron soil contamination. A total of 26 moss bag sites were established. Except for Site 22, moss bags were situated at all vegetation survey sites in order to be able to compare results. All moss bag locations are shown in Figure 1.

Moss bags were installed at each site on May 2, 1991 and then exchanged monthly until the final collection on November 5. This schedule provided six distinct monthly exposure periods; May 2 to May 31, May 31 to June 28, June 28 to August 2, August 2 to September 3, September 3 to October 3, and October 3 to November 5. All exposed bags were submitted for analysis as one group.

At all locations except at Site 18, bags were fitted to a plastic holder that was then affixed to a telephone pole or tree. At Site 18, no suitable mounting structures were unavailable. In such cases, moss bag holders are fastened to a pole driven into the ground. Regardless of the mounting arrangement, all moss bags were orientated so that the flat face of the bags faced AS and were situated approximately 3 metres from the ground. A sketch of a moss bag fitted on to a holder is shown in Figure 2.

Moss bags were submitted to the Phytotoxicology laboratory to be processed according to the Phytotoxicology Laboratory Procedure manual. Processed samples were forwarded to the Ministry's Inorganic Trace Contaminants laboratory for analysis to determine the concentrations of the same 13 elements examined in the vegetation.

4.1 Moss Bag Chemical Analysis Results

Concentrations of 10 elements detected during each of the 6 monthly exposure periods in 1991 appear in Tables 15-24. Tables containing copper, lead, nickel, zinc, and iron results also include ULN guidelines. ULN guidelines for the remaining elements in moss have not been determined. The rationale outlining the development and interpretation of the guidelines is provided in the appendix.

In order to monitor monthly emission variations for each of the 6 exposure periods, mean concentrations of 7 selected sites were computed. The 7 sites selected (1,5,8,10,12,16 and 17) are positioned in locations closest to AS and form a monitoring ring around the company. The mean monthly concentrations appear at the base of Tables 15-24.

The concentrations of some elements inherent in moss can be quite high. For example, moss not exposed to any atmospheric pollution source can contain over 100 ug/g titanium or more than 1400 ug/g aluminum. Even though some of these elements may be inherently present in considerable concentrations in moss, the range in background concentrations is usually quite narrow. This makes moss bags particularly useful for air pollution studies. Essentially, any concentration in moss above what occurs at the control sites is potentially associated with emissions from the pollution source being monitored. For example, boron moss concentrations for the six exposure periods are summarized in Table 15. The control locations are identified as Sites 18, 26 , and 27. The range in boron concentrations in moss at these three control sites for the duration of the study was 3 to 12 ug/g. Therefore, boron moss concentrations above 12 ug/g at the other study sites represent boron deposition from AS. The data that exceed the control site concentration ranges are shaded in the moss bag summary tables. The shading allows easier identification of source-oriented deposition.

Boron concentrations in moss greater than 12 ug/g reflect boron deposition from AS. Although monthly variation is evident, it is clear that Site 1 has the highest mean site concentration (100 ug/g) as well as at other sites (5,8, and 17) close to AS. With respect to monthly concentrations at the 7 sites closest to AS (1,5,8,10,12,16 and 17), the highest mean was the period from October 3 to November 5. Clearly, the data show that AS is a current source of boron. The mean moss bag boron concentrations exceeded the control values in all six periods.

Only Site 1, directly downwind of AS, had barium concentrations in moss that were, on average, consistently higher than the control sites (Table 16). Similarly, magnesium in moss (Table 24) was elevated only at one site (Site 17, close, but slightly upwind of AS). Titanium (Table 17) in moss was consistently higher than control levels at two sites, both in close proximity to AS. Zinc (Table 22) was higher than controls at two sites close to AS but also at one location (Site 20) 1.3 km north. Since this site is distant from AS, the reason for the high values is unknown, and AS is not suspected of being a zinc source. Moss aluminum concentrations were not consistently higher than control levels at any of the survey sites

Both sodium (Table 19) and nickel (Table 20) concentrations in moss exceeded the background levels at three sites, all in close proximity to AS. Copper concentrations in moss (Table 21) were consistently higher than control levels at six sample sites, all in the immediate vicinity of AS. The contamination of moss by all of these elements was marginal and the concentration gradients were very steep, indicating very localized deposition. In contrast, fluoride concentrations in moss bags, although also quite localized and close to AS, tended to be higher, relative to control levels, than most of the other elements.

5. Summary

Because of the amount of data generated by moss bag surveys, it becomes difficult to identify trends and assess the magnitude of contamination. Table 25 summarizes the moss bag data relative to the degree of contamination. Fluoride, boron, copper and nickel are definitely contaminants associated with AS. The mean concentration of these elements from the seven closest sites was more than twice the highest concentration of the control sites. Barium, titanium and sodium are marginal contaminants. The mean concentration of these elements from the seven closest sites was less than twice the highest concentration of the control sites. Aluminum, magnesium, and zinc were not contaminants, as the mean concentration of the seven closest sites was less than the highest concentration of the control sites.

As a result of a complaint investigation conducted by the Phytotoxicology Section in 1987, the AS plant in Cambridge was suspected of being a source for boron and fluoride emissions. Based on the Phytotoxicology findings, AS installed a water bath abatement system in December, 1988 to curtail gaseous and particulate emissions from the final coat spray booth areas.

In spite of the installation of abatement equipment, severe boron-like injury was still observed on vegetation at sites close to the factory in the 1989 survey. The severity and incidence of injury declined in all directions with increased distance from the source. Concentrations of boron above the ULN guideline continued to be found in foliage at most sites close to the plant. Excessive concentrations of fluoride were found in both the 1989 and 1990 vegetation at close-in sites. In addition, elevated concentrations of barium, titanium, sodium, nickel, zinc, and copper were present in vegetation at sites close to the factory.

Following a slight decline in 1990, boron concentrations in the 1991 vegetation increased to near 1989 levels. Although AS may still be a source of current emissions, vegetation cannot be used as the sole monitoring parameter to separate current from historic emissions. Of the total amount of boron detected in the post-abatement foliage, an unknown amount would have been absorbed from the contaminated soil and the remainder from current emissions.

In 1991, moss bags were introduced in the survey area to assess the effectiveness of the abatement system installed at AS. Mean boron concentrations at moss bag sites close to the factory were sharply higher than at more distant locations and control sites. Similarly, mean concentrations of other elements such as barium, titanium, fluoride, sodium, nickel and copper were highest at Site 1, and at most other sites close to the factory. Because of the grouping effect of higher concentrations of some elements at sites closest to the plant, it was concluded that AS continued to be a source of process-related current emissions in 1991.

Figure: 1 Locations of Vegetation and Moss Bag Survey Sites in the Vicinity of American-Standard, Cambridge - 1991.

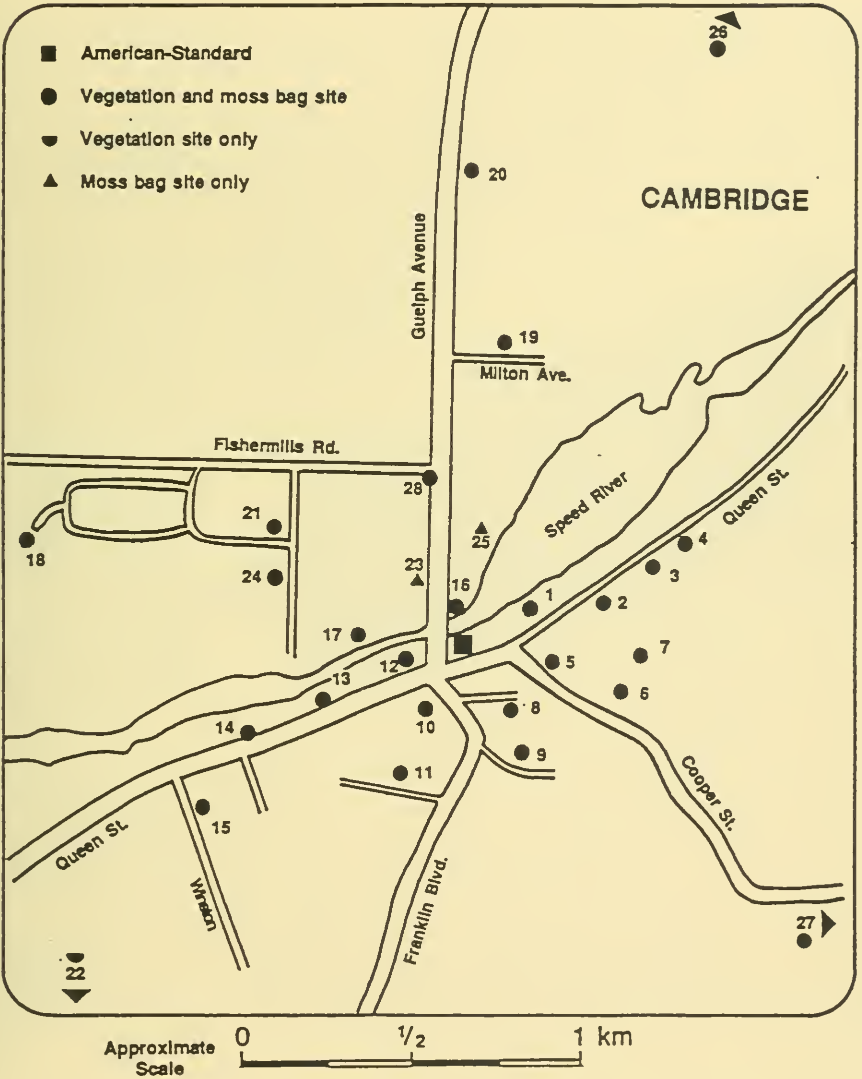

FIGURE: 2 Sketch Showing Appearance of Moss Bags and Plastic Holder

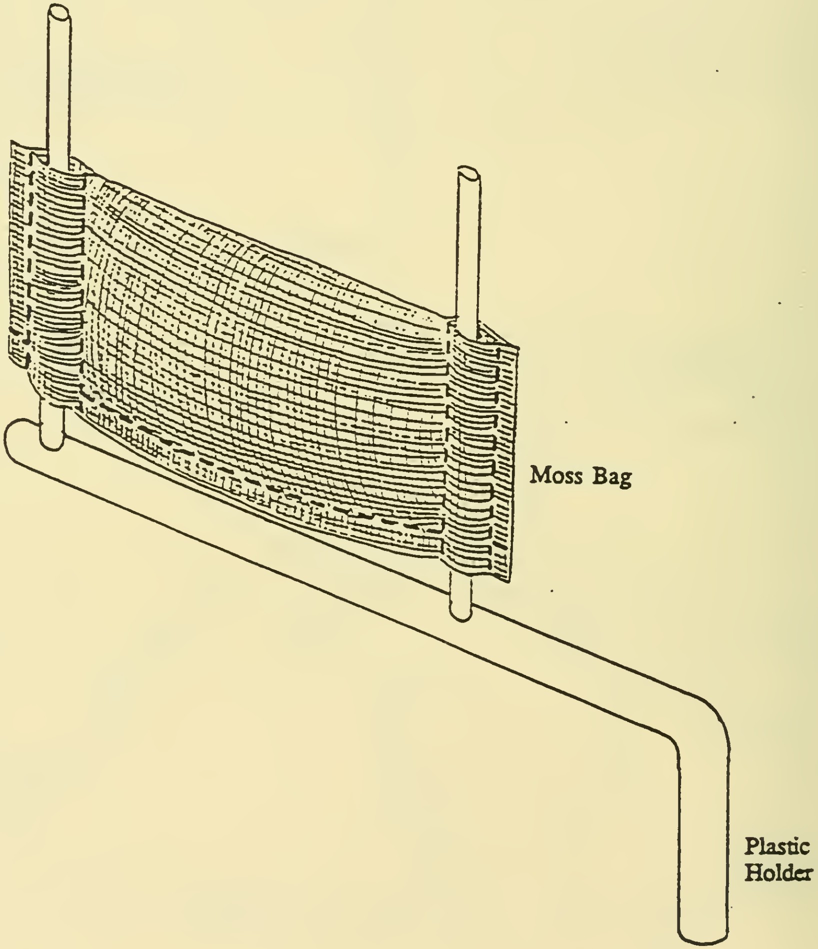

Table: 1 Observational Notes of Survey Foliage Examined in the Vicinity of American-Standard, Cambridge 1991

Survey Site Number	Distance & Direction from A-S	Vegetation Examined	Observations
1	200 m NE	amur maple	<35% T,M,I necrosis on all foliage.
2	400 m NE	Norway maple	<35% T,M,I combined necrosis & senescence
3	660 m NE	Norway maple	Up to 25% T,M,I necrosis on most older foliage. 2-10% T&M on younger foliage.
4	700 m NE	silver maple	<1% T necrosis and senescence
5	225 m E	Norway maple	Up to 35% T,M,I necrosis on most older foliage.
6	450 m E	Norway maple	Up to 35% T,M,I necrosis due to senescence
7	500 m E	silver maple	No visible air pollution injury to foliage.
8	150 m SE	silver maple	2-10% T,M necrosis on most older foliage. >0-1% T,M necrosis on younger foliage.
		Norway maple	<35% T,M,I necrosis on most older foliage. 2-10% T,M necrosis on most younger foliage.
9	300 m SE	silver maple	2-10% T,M,I necrosis on most foliage.
10	150 m SSW	Norway maple	No visible air pollution injury to foliage.
11	400 SSW	Norway maple	2-10% T,M necrosis due to senescence.
12	125 m SW	Manitoba maple	<35% T,M,I necrosis on older foliage only.
13	400 m SW	silver maple	No visible air pollution injury to foliage.
14	600 m SW	Norway maple	Up to 35% T,M,I necrosis on older foliage. Up to 10% T,M necrosis on younger foliage. May be combined senescence/drought effects.
15	850 m SW	silver maple	No visible air pollution injury to foliage.
16	60 m N	amur maple	<35% T,M,I necrosis mainly on older foliage.
17	250 m W	silver maple	T,M necrosis due to senescence.
		Norway maple	>0-1% I necrotic blotching.
18*	1.2 km W	silver maple	No visible air pollution injury to foliage.
		Norway maple	No visible air pollution injury to foliage.
19	850 m N	Norway maple	Up to 5% T,M,I necrosis - drought/senescence.

*Control site.

T - terminal, M - marginal, I - intercostal.

Table: 1 (cont'd)

Survey Site Number	Distance & Direction from A-S	Vegetation Examined	Observations
20	1.3 km N	silver maple Norway maple	No visible air pollution injury to foliage. No visible air pollution injury to foliage.
21	600 m NW	silver maple	No visible air pollution injury to foliage.
22*	7.8 km SSW	amur maple	No visible air pollution injury to foliage.
24	500 m W	Norway maple Manitoba maple	0-2% I necrosis due to senescence. No visible air pollution injury to foliage.
26*	2.1 km N	Manitoba maple	No visible air pollution injury to foliage.
27*	2.0 km SE	silver maple	No visible air pollution injury to foliage.
28	500 m NNW	Norway maple Manitoba maple	2-10% T,M,I necrosis on scattered foliage. 0-1% T necrosis due to senescence.

*Control sites.

T - terminal, M - marginal, I - intercostal

Table: 2 Boron Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Boron Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	895	525	625
2	400 m NE	Norway maple	395	525	745
3	600 m NE	Norway maple	270	155	280
4	700 m NE	silver maple	115	103	145
5	225 m E	Norway maple	645	305	515
6	450 m E	Norway maple	175	140	165
7	500 m E	silver maple	70	50	82
8	150 m SE	silver maple Norway maple	595 NR	605 360	625 375
9	300 m SE	silver maple	240	365	515
10	150 m SSW	silver maple	255	230	245
11	400 m SSW	Norway maple	149	125	135
12	125 M SW	Man. maple	905	NR	1045
13	400 m SW	silver maple	190	120	150
14	600 m SW	Norway maple	270	155	200
15	850 m SW	silver maple	120	46	49
16	60 m N	amur maple	1300	1050	1000
17	250 m W	silver maple Man. maple	335 NR	295 NR	320 525
18**	1.2 km W	silver maple Norway maple	27 48	47 38	35 51
19	850 m N	silver maple Norway maple	NR NR	38 82	NR 96
20	1.3 km N	silver maple Norway maple	NR NR	53 56	54 87
21	600 m NW	silver maple	NR	50	48
22**	7.8 km SSW	amur maple	28	41	42
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	105 135
26**	2.1 km N	Man. Maple	NR	NR	56
27**	2.0 km SE	silver maple	NR	NR	104
28	500 m NNW	Norway maple Man. maple	NR NR	NR	300 260
MEAN - Sites 1,5,8,10,12,16 & 17			704	481	659

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.

**control sites. ULN - Phytotoxicology Upper Limit of Normal guideline for boron is 175 ppm, see appendix.

Shaded values exceed the ULN guideline.

Table: 3

Fluoride Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Fluoride Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	68	41	57
2	400 m NE	Norway maple	12	12*	22
3	600 m NE	Norway maple	3	3	5
4	700 m NE	silver maple	4	8	17
5	225 m E	Norway maple	31	12	32
6	450 m E	Norway maple	6	3	7
7	500 m E	silver maple	3	3	5
8	150 m SE	silver maple Norway maple	67 NR	35 66	44 65
9	300 m SE	silver maple	20	29	34
10	150 m SSW	silver maple	8	7	15
11	400 m SSW	Norway maple	5	4	6
12	125 M SW	Man. maple	200	NR	97
13	400 m SW	silver maple	14	5	13
14	600 m SW	Norway maple	8	4	7
15	850 m SW	silver maple	3	3	7
16	60 m N	amur maple	33	6	15
17	250 m W	silver maple Man. maple	14 NR	7 NR	10 13
18**	1.2 km W	silver maple Norway maple	4 2	2 2	4 4
19	850 m N	silver maple Norway maple	NR NR	3 2	NR 4
20	1.3 km N	silver maple Norway maple	NR NR	3 2	7 4
21	600 m NW	silver maple	NR	2	6
22**	7.8 km SSW	amur maple	5	2	5
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	3 10
26**	2.1 km N	Man. Maple	NR	NR	7
27**	2.0 km SE	silver maple	NR	NR	9
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	6 10
MEAN - Sites 1,5,8,10,12,16 & 17			60	25	39

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.
**control sites. ULN - Phytotoxicology Upper Limit of Normal guideline for fluoride is 35 ppm, see appendix.
Shaded values exceed the ULN.

Table: 4 Barium Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Barium Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	48	58	50
2	400 m NE	Norway maple	9	16	21
3	600 m NE	Norway maple	10	9	14
4	700 m NE	silver maple	4	6	7
5	225 m E	Norway maple	17	18	26
6	450 m E	Norway maple	7	6	7
7	500 m E	silver maple	2	3	4
8	150 m SE	silver maple Norway maple	17 NR	26 35	19 30
9	300 m SE	silver maple	9	21	17
10	150 m SSW	silver maple	5	9	11
11	400 m SSW	Norway maple	12	13	19
12	125 M SW	Man. maple	47	NR	54
13	400 m SW	silver maple	8	5	11
14	600 m SW	Norway maple	20	14	23
15	850 m SW	silver maple	11	10	8
16	60 m N	amur maple	3	28	21
17	250 m W	silver maple Man. maple	20 NR	18 NR	18 45
18**	1.2 km W	silver maple Norway maple	3 8	4 8	3 9
19	850 m N	silver maple Norway maple	NR NR	9 8	NR 13
20	1.3 km N	silver maple Norway maple	NR NR	6 8	7 12
21	600 m NW	silver maple	NR	6	8
22**	7.8 km SSW	amur maple	3	4	4
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	9 12
26**	2.1 km N	Man. Maple	NR	NR	8
27**	2.0 km SE	silver maple	NR	NR	7
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	10 30
MEAN - Sites 1,5,8,10,12,16 & 17			27	27	30

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.

**control sites. ULN - Phytotoxicology Upper Limit of Normal guideline for barium has not been established.

Table: 5

Nickel Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Nickel Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	6	7	9
2	400 m NE	Norway maple	1	2	4
3	600 m NE	Norway maple	1	1	3
4	700 m NE	silver maple	1	1	2T
5	225 m E	Norway maple	3	3	3T
6	450 m E	Norway maple	1	1	2T
7	500 m E	silver maple	1	1	1T
8	150 m SE	silver maple Norway maple	2 NR	3 4	2T 3
9	300 m SE	silver maple	1	2	2T
10	150 m SSW	silver maple	1	1	2T
11	400 m SSW	Norway maple	1	1	2T
12	125 M SW	Man. maple	5	NR	4
13	400 m SW	silver maple	1	1	2T
14	600 m SW	Norway maple	1	2	2T
15	850 m SW	silver maple	1	1	1T
16	60 m N	amur maple	▨ 9	4	3T
17	250 m W	silver maple Man. maple	2 NR	2 NR	1T 2T
18**	1.2 km W	silver maple Norway maple	1 1	1 1	2T 2T
19	850 m N	silver maple Norway maple	NR NR	1 1	NR 2T
20	1.3 km N	silver maple Norway maple	NR NR	1 1	2T 2T
21	600 m NW	silver maple	NR	1	2T
22**	7.8 km SSW	amur maple	1	1	2T
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	2T 2T
26**	2.1 km N	Man. Maple	NR	NR	2T
27**	2.0 km SE	silver maple	NR	NR	2T
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	2T 3
MEAN - Sites 1,5,8,10,12,16 & 17			4	3	3

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.
**control sites. ULN - Phytotoxicology Upper Limit of Normal guideline for nickel is 7 ppm, see appendix.
Shaded values exceed the ULN. T- a measurable trace amount, interpret with caution.

Table: 6 Titanium Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Titanium Concentration[*]		
			1989	1990	1991
1	200 m NE	amur maple	31	29	42
2	400 m NE	Norway maple	13	13	19
3	600 m NE	Norway maple	6	<4	5T
4	700 m NE	silver maple	8	7	7
5	225 m E	Norway maple	20	12	17
6	450 m E	Norway maple	5	4	8
7	500 m E	silver maple	4	1	4T
8	150 m SE	silver maple Norway maple	19 NR	13 22	18 19
9	300 m SE	silver maple	9	14	13
10	150 m SSW	silver maple	6	5	8
11	400 m SSW	Norway maple	7	5	7
12	125 M SW	Man. maple	14	NR	14
13	400 m SW	silver maple	11	6	9
14	600 m SW	Norway maple	8	10	8
15	850 m SW	silver maple	8	10	7
16	60 m N	amur maple	30	17	23
17	250 m W	silver maple Man. maple	13 NR	7 NR	9 10
18[**]	1.2 km W	silver maple Norway maple	5 5	4 4	5 7
19	850 m N	silver maple Norway maple	NR NR	7 6	NR 5T
20	1.3 km N	silver maple Norway maple	NR NR	7 7	9 11
21	600 m NW	silver maple	NR	5	8
22[**]	7.8 km SSW	amur maple	8	5	5T
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	5 14
26[**]	2.1 km N	Man. Maple	NR	NR	11
27[**]	2.0 km SE	silver maple	NR	NR	7
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	12 17
MEAN - Sites 1,5,8,10,12,16 & 17			19	15	18

[*] ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.

[**] control sites. Phytotoxicology Upper Limit of Normal (ULN) guideline for titanium has not be established.

T - a measurable trace amount, interpret with caution.

Table: 7

Zinc Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Zinc Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	53	56	21
2	400 m NE	Norway maple	32	30	26
3	600 m NE	Norway maple	17	13	17
4	700 m NE	silver maple	33	31	37
5	225 m E	Norway maple	26	33	37
6	450 m E	Norway maple	12	12	15
7	500 m E	silver maple	32	48	38
8	150 m SE	silver maple	56	77	47
		Norway maple	NR	35	29
9	300 m SE	silver maple	36	79	77
10	150 m SSW	silver maple	26	29	24
11	400 m SSW	Norway maple	23	23	32
12	125 M SW	Man. maple	50	NR	40
13	400 m SW	silver maple	32	28	37
14	600 m SW	Norway maple	26	21	28
15	850 m SW	silver maple	10	39	34
16	60 m N	amur maple	56	55	71
17	250 m W	silver maple	83	73	43
		Man. maple	NR	NR	41
18**	1.2 km W	silver maple	24	21	28
		Norway maple	13	15	13
19	850 m N	silver maple	NR	16	NR
		Norway maple	NR	13	12
20	1.3 km N	silver maple	NR	33	36
		Norway maple	NR	23	16
21	600 m NW	silver maple	NR	23	40
22**	7.8 km SSW	amur maple	16	15	23
24	500 m NW	Norway maple	NR	NR	24
		Man. maple	NR	NR	42
26**	2.1 km N	Man. Maple	NR	NR	21
27**	2.0 km SE	silver maple	NR	NR	34
28	500 m NNW	Norway maple	NR	NR	16
		Man. maple	NR	NR	48
MEAN - Sites 1,5,8,10,12,16 & 17			50	51	39

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.

**control sites.

ULN - Phytotoxicology Upper Limit of Normal guideline for zinc is 250 ppm, see appendix.

Table: 8 Lead Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Lead Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	<2	<3	3T
2	400 m NE	Norway maple	<2	<1	2T
3	600 m NE	Norway maple	<1	<1	1T
4	700 m NE	silver maple	>1	<1	2T
5	225 m E	Norway maple	<2	<2	2T
6	450 m E	Norway maple	<1	<2	1T
7	500 m E	silver maple	<1	<2	1T
8	150 m SE	silver maple Norway maple	<1 NR	<1 <2	3T 3T
9	300 m SE	silver maple	>1	<1	1T
10	150 m SSW	silver maple	>1	<1	1T
11	400 m SSW	Norway maple	<2	<1	1T
12	125 M SW	Man. maple	3	NR	2T
13	400 m SW	silver maple	<2	<2	2T
14	600 m SW	Norway maple	2	<2	2T
15	850 m SW	silver maple	<2	<2	1T
16	60 m N	amur maple	<4	<3	2T
17	250 m W	silver maple Man. maple	<3 NR	<2 NR	1T DL
18**	1.2 km W	silver maple Norway maple	>1 >1	<1 <1	DL DL
19	850 m N	silver maple Norway maple	NR NR	<1 <1	NR 2T
20	1.3 km N	silver maple Norway maple	NR NR	<1 <1	1T 2T
21	600 m NW	silver maple	NR	<2	1T
22**	7.8 km SSW	amur maple	>2	<1	1T
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	1T DL
26**	2.1 km N	Man. Maple	NR	NR	2T
27**	2.0 km SE	silver maple	NR	NR	1T
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	1T 3
MEAN - Sites 1,5,8,10,12,16 & 17			<2	<2	<2

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.
**control sites. T - a measurable trace amount, interpret with caution. DL - below analytical detection limit.
ULN - Phytotoxicology Upper Limit of Normal guideline for lead is 60 ppm, see appendix.

Table: 9 Copper Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Copper Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	8	6	7
2	400 m NE	Norway maple	6	6	5
3	600 m NE	Norway maple	3	3	3T
4	700 m NE	silver maple	5	3	3
5	225 m E	Norway maple	6	5	5
6	450 m E	Norway maple	5	6	7
7	500 m E	silver maple	10	5	5
8	150 m SE	silver maple Norway maple	7 NR	9 9	8 8
9	300 m SE	silver maple	4	6	6
10	150 m SSW	silver maple	4	3	2T
11	400 m SSW	Norway maple	5	5	6
12	125 M SW	Man. maple	8	NR	6
13	400 m SW	silver maple	3	1	2T
14	600 m SW	Norway maple	5	4	5
15	850 m SW	silver maple	3	8	4
16	60 m N	amur maple	10	7	7
17	250 m W	silver maple Man. maple	5 NR	4 NR	3T 6
18**	1.2 km W	silver maple Norway maple	4 5	4 4	4 3
19	850 m N	silver maple Norway maple	NR NR	3 4	NR 3
20	1.3 km N	silver maple Norway maple	NR NR	4 6	4 7
21	600 m NW	silver maple	NR	7	5
22**	7.8 km SSW	amur maple	4	4	9
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	7 6
26**	2.1 km N	Man. Maple	NR	NR	4
27**	2.0 km SE	silver maple	NR	NR	7
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	2T 7
MEAN - Sites 1,5,8,10,12,16 & 17			7	6	6

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.

**control sites. ULN - Phytotoxicology Upper Limit of Normal guideline for copper is 20 ppm, see appendix.

T - a measurable trace amount, interpret with caution.

Table: 10 Magnesium Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Fluoride Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	0.3	0.3	0.2
2	400 m NE	Norway maple	0.2	0.2	0.3
3	600 m NE	Norway maple	0.3	0.3	0.3
4	700 m NE	silver maple	0.3	0.5	0.5
5	225 m E	Norway maple	0.2	0.3	0.2
6	450 m E	Norway maple	0.2	0.2	0.2
7	500 m E	silver maple	0.2	0.2	0.2
8	150 m SE	silver maple Norway maple	0.3 NR	0.4 0.3	0.3 0.3
9	300 m SE	silver maple	0.2	0.4	0.4
10	150 m SSW	silver maple	0.3	0.3	0.3
11	400 m SSW	Norway maple	0.2	0.3	0.3
12	125 M SW	Man. maple	0.6	NR	0.7
13	400 m SW	silver maple	0.3	0.3	0.4
14	600 m SW	Norway maple	0.3	0.3	0.3
15	850 m SW	silver maple	0.2	0.3	0.2
16	60 m N	amur maple	0.2	0.2	0.2
17	250 m W	silver maple Man. maple	0.2 NR	0.2 NR	0.2 0.4
18**	1.2 km W	silver maple Norway maple	0.2 0.3	0.3 0.3	0.2 0.2
19	850 m N	silver maple Norway maple	NR NR	0.4 0.2	NR 0.3
20	1.3 km N	silver maple Norway maple	NR NR	0.4 0.2	0.4 0.2
21	600 m NW	silver maple	NR	0.4	0.4
22**	7.8 km SSW	amur maple	0.5	0.4	0.2
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	0.2 0.5
26**	2.1 km N	Man. Maple	NR	NR	0.4
27**	2.0 km SE	silver maple	NR	NR	0.3
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	0.3 0.7
MEAN - Sites 1,5,8,10,12,16 & 17			0.3	0.3	0.3

*percent (%), dry weight, mean of duplicate samples and analysis. NR - no results. analysis not conducted.
**control sites.
ULN - Phytotoxicology Upper Limit of Normal guideline for magnesium is 0.7%, see appendix.

Table: 11

Aluminum Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Aluminum Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	105	115	103
2	400 m NE	Norway maple	62	67	81
3	600 m NE	Norway maple	50	34	34
4	700 m NE	silver maple	53	59	52
5	225 m E	Norway maple	76	70	61
6	450 m E	Norway maple	54	47	46
7	500 m E	silver maple	31	13T	27
8	150 m SE	silver maple Norway maple	53 NR	48 82	73 66
9	300 m SE	silver maple	43	63	65
10	150 m SSW	silver maple	36	36	46
11	400 m SSW	Norway maple	50	39	47
12	125 M SW	Manitoba maple	85	NR	58
13	400 m SW	silver maple	46	40	66
14	600 m SW	Norway maple	57	84	67
15	850 m SW	silver maple	56	56	72
16	60 m N	amur maple	125	98	107
17	250 m W	silver maple Manitoba maple	155 NR	105 NR	104 99
18**	1.2 km W	silver maple Norway maple	47 55	28 34	36 67
19	850 m N	silver maple Norway maple	NR NR	64 55	NR 45
20	1.3 km N	silver maple Norway maple	NR NR	58 54	76 105
21	600 m NW	silver maple	NR	30	53
22**	7.8 km SSW	amur maple	56	43	39
24	500 m NW	Norway maple Manitoba maple	NR NR	NR NR	38 95
26**	2.1 km N	Manitoba Maple	NR	NR	105
27**	2.0 km SE	silver maple	NR	NR	49
28	500 m NNW	Norway maple Manitoba maple	NR NR	NR NR	88 115
MEAN - Sites 1,5,8,10,12,16 & 17			91	79	80

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.
**control sites.
ULN - Phytotoxicology Upper Limit of Normal guideline for aluminum is 500 ppm, see appendix.

Table: 12

Iron Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Iron Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	175	175	170
2	400 m NE	Norway maple	105	130	130
3	600 m NE	Norway maple	130	83	88
4	700 m NE	silver maple	115	95	88
5	225 m E	Norway maple	135	115	115
6	450 m E	Norway maple	95	83	88
7	500 m E	silver maple	130	90	130
8	150 m SE	silver maple Norway maple	115 NR	97 145	140 140
9	300 m SE	silver maple	90	125	115
10	150 m SSW	silver maple	70	72	83
11	400 m SSW	Norway maple	100	94	120
12	125 M SW	Man. maple	130	NR	165
13	400 m SW	silver maple	120	89	130
14	600 m SW	Norway maple	100	145	120
15	850 m SW	silver maple	120	113	110
16	60 m N	amur maple	225	190	225
17	250 m W	silver maple Man. maple	505 NR	470 NR	435 425
18**	1.2 km W	silver maple Norway maple	95 95	84 74	83 106
19	850 m N	silver maple Norway maple	NR NR	110 90	NR 88
20	1.3 km N	silver maple Norway maple	NR NR	110 110	120 160
21	600 m NW	silver maple	NR	101	105
22**	7.8 km SSW	amur maple	140	110	72
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	97 230
26**	2.1 km N	Man. Maple	NR	NR	190
27**	2.0 km SE	silver maple	NR	NR	106
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	160 300
MEAN - Sites 1,5,8,10,12,16 & 17			194	181	211

*ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.

**control sites. ULN - Phytotoxicology Upper Limit of Normal guideline, for iron is 1000 ppm, see appendix.

Table: 13

Sulphur Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Sulphur Concentration*		
			1989	1990	1991
1	200 m NE	amur maple	0.1	0.2	0.2
2	400 m NE	Norway maple	0.1	0.1	0.1
3	600 m NE	Norway maple	0.1	0.1	0.2
4	700 m NE	silver maple	0.1	0.1	0.1
5	225 m E	Norway maple	0.2	0.2	0.2
6	450 m E	Norway maple	0.1	0.2	0.2
7	500 m E	silver maple	0.1	0.2	0.2
8	150 m SE	silver maple Norway maple	0.1 NR	0.2 0.2	0.2 0.2
9	300 m SE	silver maple	0.1	0.2	0.2
10	150 m SSW	silver maple	0.1	0.1	0.1
11	400 m SSW	Norway maple	0.1	0.2	0.2
12	125 M SW	Man. maple	0.1	NR	0.2
13	400 m SW	silver maple	0.2	0.2	0.2
14	600 m SW	Norway maple	0.1	0.2	0.2
15	850 m SW	silver maple	0.1	0.3	0.2
16	60 m N	amur maple	0.1	0.1	0.1
17	250 m W	silver maple Man. maple	0.1 NR	0.1 NR	0.1 0.2
18**	1.2 km W	silver maple Norway maple	0.1 0.1	0.2 0.2	0.1 0.2
19	850 m N	silver maple Norway maple	NR NR	0.2 O.2	NR 0.2
20	1.3 km N	silver maple Norway maple	NR NR	0.2 0.2	0.1 0.2
21	600 m NW	silver maple	NR	0.2	0.2
22**	7.8 km SSW	amur maple	0.1	0.1	0.1
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	0.2 0.2
26**	2.1 km N	Man. Maple	NR	NR	0.2
27**	2.0 km SE	silver maple	NR	NR	0.1
28	500 m NNW	Norway maple Man. maple	NR NR	NR NR	0.2 0.2
MEAN - Sites 1,5,8,10,12,16 & 17			0.1	0.2	0.2

*percent (%), dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.

**control sites. ULN - Phytotoxicology Upper Limit of Normal guideline for sulphur is 0.4%, see appendix.

Table: 14

Sodium Concentrations in Unwashed Foliage Collected in the Vicinity of American-Standard, Cambridge - 1989-1991

Sample Site Number	Distance & Direction from A-S	Vegetation Species Sampled	Sodium Concentration[*]		
			1989	1990	1991
1	200 m NE	amur maple	NR	44	100
2	400 m NE	Norway maple	NR	45	53
3	600 m NE	Norway maple	NR	10	17
4	700 m NE	silver maple	NR	12	11T
5	225 m E	Norway maple	NR	30	73
6	450 m E	Norway maple	NR	9	7T
7	500 m E	silver maple	NR	6	8T
8	150 m SE	silver maple Norway maple	NR NR	42 40	13T 17
9	300 m SE	silver maple	NR	29	18
10	150 m SSW	silver maple	NR	18	15T
11	400 m SSW	Norway maple	NR	24	39
12	125 M SW	Man. maple	NR	NR	52
13	400 m SW	silver maple	NR	49	83
14	600 m SW	Norway maple	NR	25	32
15	850 m SW	silver maple	NR	20	45
16	60 m N	amur maple	NR	63	65
17	250 m W	silver maple Man. maple	NR NR	38 NR	38 82
18[**]	1.2 km W	silver maple Norway maple	NR NR	7 10	7T 23
19	850 m N	silver maple Norway maple	NR NR	11 210	NR 27
20	1.3 km N	silver maple Norway maple	NR NR	10 7	18 10T
21	600 m NW	silver maple	NR	64	38
22[**]	7.8 km SSW	amur maple	NR	14	41
24	500 m NW	Norway maple Man. maple	NR NR	NR NR	11T 30
26[**]	2.1 km N	Man. Maple	NR	NR	29
27[**]	2.0 km SE	silver maple	NR	NR	12
28	500 m NNW	Norway maple Man. maple	NR	NR NR	27 43
MEAN - Sites 1,5,8,10,12,16 & 17			NR	39	51

[*] ug/g, dry weight, mean of duplicate samples and analysis. NR - no results, analysis not conducted.

[**] control sites. ULN - Phytotoxicology Upper Limit of Normal guideline for sodium is 350 ppm, see appendix.

T - a measurable trace amount, interpret with caution.

Table: 15 Concentrations* of Boron in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						
Moss Bag Site No.	May 2- May 31	May 31- June 28	June 28- August 2	August 2- Sept. 3	Sept. 3- Oct. 3	Oct. 3- Nov. 5	SITE MEAN
1	94	85	110	71	100	140	**100**
2	23	14	10	4T	16	18	**14**
3	8	5T	4T	15	7	13	**9**
4	5	5T	4T	6	6	14	**7**
5	14	9	12	11	43	23	**19**
6	DL	5T	4T	5T	7	7	**6**
7	DL	3T	4T	6	6	5T	**5**
8	20	23	16	15	20	26	**20**
9	21	11	11	9	9	23	**14**
10	6	8	9	9	11	7	**8**
11	6	6	6	4T	4T	9	**6**
12	13	12	9	11	20	27	**15**
13	7	7	5T	8	8	7	**7**
14	DL	6	2T	3T	6	10	**5**
15	5T	4T	5T	5T	4T	5T	**5**
16	9	20	9	13	14	19	**14**
17	NR	11	6	9	8	46	**16**
18**	6	7	6	4T	10	7	**7**
19	6	6	3T	4T	10	7	**6**
20	5	8	4T	5T	10	3T	**6**
23	8	7	8	8	11	6	**8**
24	6	7	6	5T	7	11	**7**
25	NR	9	12	9	8	12	**10**
26**	NR	6	3T	12	6	10	**7**
27**	NR	3T	4T	4T	10	9	**6**
28	8	6	6	5T	8	8	**7**
MEAN - SITES 1,5,8,10, 12,16,17	**26**	**24**	**24**	**20**	**31**	**41**	

*ug/g, dry weight.
**control sites.
Shaded data exceed highest background values.

NR - no results, analysis not conducted.
DL - below analytical detection limit.

T - a measurable trace amount, interpret with caution.

Table: 16 Concentrations* of Barium in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						
Moss Bag Site No.	May 2-May 31	May 31-June 28	June 28-August 2	August 2-Sept. 3	Sept. 3-Oct. 3	Oct. 3-Nov. 5	SITE MEAN
1	130	130	160	85	85	110	117
2	56	40	44	NR	38	44	44
3	37	33	28	25	30	48	34
4	34	35	29	29	28	48	34
5	45	35	44	33	50	53	43
6	42	31	34	29	29	31	33
7	37	29	31	28	31	33	32
8	59	49	50	33	33	56	47
9	47	36	34	29	27	48	37
10	47	41	39	35	35	35	39
11	44	33	27	25	30	33	32
12	40	42	30	30	28	37	35
13	43	32	32	34	32	32	34
14	38	34	33	25	31	45	34
15	47	31	41	27	30	30	34
16	42	41	45	29	32	48	40
17	NR	50	40	29	38	52	42
18**	44	46	44	27	36	32	38
19	41	37	27	26	35	26	32
20	39	48	28	27	34	28	34
23	56	35	43	32	33	33	39
24	66	49	49	30	39	28	44
25	NR	31	50	30	30	51	38
26**	NR	51	26	26	37	31	34
27**	NR	32	23	26	38	44	33
28	69	50	50	25	31	28	42
MEAN - SITES 1,5,8,10 12,16,17	61	55	58	39	43	56	

*ug/g, dry weight.
**control sites.

NR - no results, analysis not conducted.
Shaded data exceed highest background values.

Table: 17 Concentrations* of Titanium in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						
Moss Bag Site No.	May 2- May 31	May 31- June 28	June 28- August 2	August 2- Sept. 3	Sept. 3- Oct. 3	Oct. 3- Nov. 5	SITE MEAN
1	160	170	290	120	110	160	**185**
2	91	82	110	NR	96	79	**92**
3	80	73	81	84	77	73	**78**
4	77	65	95	78	70	67	**75**
5	74	65	100	110	130	87	**94**
6	55	62	62	72	75	81	**68**
7	54	68	87	85	110	76	**80**
8	92	83	79	92	88	90	**87**
9	97	76	99	87	75	58	**82**
10	110	82	150	82	120	85	**105**
11	66	60	88	75	74	79	**74**
12	84	72	83	82	78	73	**79**
13	NR	79	89	80	75	76	**80**
14	66	78	80	85	87	67	**77**
15	95	76	79	84	81	66	**80**
16	74	77	87	91	84	71	**81**
17	NR	130	130	99	120	110	**118**
18**	91	110	66	89	89	NR	**89**
19	70	60	87	82	69	94	**77**
20	89	NR	85	82	82	85	**85**
23	77	97	89	83	130	120	**99**
24	67	77	62	85	91	88	**78**
25	NR	81	83	90	96	70	**84**
26**	NR	72	71	89	99	110	**88**
27**	NR	67	100	85	120	67	**88**
28	57	91	76	63	120	110	**86**
MEAN - SITES 1,5,8,10 12,16, 17	99	97	131	97	104	97	

*ug/g, dry weight.
**control sites.

NR - no results, analysis not conducted.
Shaded data exceed highest background values.

Table: 18 Concentrations* of Fluoride in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						SITE MEAN
Moss Bag Site No.	May 2- May 31	May 31- June 28	June 28- August 2	August 2- Sept. 3	Sept. 3- Oct. 3	Oct. 3- Nov. 5	
1	91	98	100	71	89	180	105
2	32	30	25	NR	38	54	36
3	15	13	9	15	13	31	16
4	9	8	8	14	12	20	12
5	36	19	37	43	130	67	55
6	8	8	7	13	25	22	14
7	6	6	9	12	26	16	13
8	56	6	35	30	120	100	48
9	65	30	61	23	31	77	48
10	18	22	25	19	41	30	36
11	10	10	12	14	17	21	14
12	17	24	20	24	26	61	30
13	10	18	11	19	13	26	16
14	7	9	6	14	11	16	11
15	6	11	8	13	18	11	11
16	16	17	16	15	25	38	21
17	NR	16	13	15	25	74	29
18**	5	9	5	11	9	18	10
19	8	5	7	10	12	26	11
20	7	7	9	11	16	20	12
23	10	12	13	15	32	27	18
24	5	12	5	14	17	23	15
25	NR	10	13	12	17	26	16
26**	NR	7	8	13	17	27	14
27**	NR	6	11	16	24	17	15
28	8	9	8	14	23	29	15
MEAN - SITES 1,5,8,10 12,16,17	39	29	35	31	65	79	

*ug/g, dry weight.
**control sites.

NR - no results, analysis not conducted.
Shaded data exceed highest background values.

Table: 19 Concentrations* of Sodium in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						
Moss Bag Site No.	May 2-May 31	May 31-June 28	June 28-August 2	August 2-Sept. 3	Sept. 3-Oct. 3	Oct. 3-Nov. 5	SITE MEAN
1	600	300	300	360	500	800	**477**
2	260	110	40	NR	260	260	**186**
3	270	130	29	110	220	370	**188**
4	200	110	24	150	150	240	**146**
5	300	64	45	90	290	210	**167**
6	160	100	32	100	230	230	**142**
7	220	120	45	100	250	180	**153**
8	310	130	49	150	230	360	**205**
9	310	130	57	140	200	330	**195**
10	260	83	35	84	210	150	**137**
11	170	160	58	160	180	200	**155**
12	320	120	54	210	250	430	**231**
13	200	150	43	160	190	280	**171**
14	210	100	21	120	270	290	**169**
15	150	93	26	140	220	240	**145**
16	290	250	38	210	240	350	**230**
17	NR	230	59	140	300	200	**186**
18**	170	110	35	71	81	83	**92**
19	240	180	24	190	280	150	**177**
20	130	260	26	130	160	97	**152**
23	70	84	56	110	240	92	**119**
24	NR	160	40	150	300	180	**150**
25	NR	160	73	150	200	250	**167**
26**	NR	150	22	150	190	170	**136**
27**	71	130	28	96	220	190	**133**
28	71	140	50	160	160	150	**122**
MEAN - SITES 1,5,8,10 12,16,17	**347**	**168**	**83**	**178**	**289**	**357**	

*ug/g, dry weight.
**control sites.

NR - no results, analysis not conducted.
Shaded data exceed highest background values.

Table: 20 Concentrations[*] of Nickel in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						SITE MEAN
Moss Bag Site No.	May 2- May 31	May 31- June 28	June 28- August 2	August 2- Sept. 3	Sept. 3- Oct. 3	Oct. 3- Nov. 5	
1	28	27	36	16	19	29	26
2	6	6	6	NR	5	7	6
3	4	3	4	3	4	4	4
4	4	3	3	3	4	5	4
5	5	5	6	5	9	7	6
6	4	3	2T	4	4	4	4
7	3	3	3	3	4	4	3
8	7	7	6	4	6	5	6
9	9	7	10	4	5	7	7
10	5	6	5	3	6	6	5
11	5	4	3	3	3	3	4
12	5	6	4	4	5	5	5
13	6	5	3	3	3	4	4
14	3	3	3T	3	3	4	3
15	3	4	3	3	3	4	3
16	4	4	5	4	4	6	5
17	NR	5	6	5	8	10	7
18[**]	6	6	3	3	4	4	4
19	4	3	3	3	3	4	3
20	3	4	3	3	4	3	3
23	5	5	6	4	7	5	5
24	5	6	5	4	6	6	5
25	NR	6	4	4	4	6	5
26[**]	NR	4	3	4	4	3	4
27[**]	NR	3	3T	4	4	4	4
28	4	5	4	3	4	4	4
MEAN - SITES 1,5,8,10 12,16,17	**9**	**9**	**10**	**6**	**8**	**10**	

[*] ug/g, dry weight.
[**] control sites.
NR - no results, analysis not conducted.
Underlined values exceed ULN guidelines.
T - a measurable trace amount, interpret with caution.
Shaded data exceed highest background values.
ULN - Phytotoxicology Upper Limit of Normal guideline for nickel in moss is 13 ppm

Table: 21 Concentrations* of Copper in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						SITE MEAN
Moss Bag Site No.	May 2- May 31	May 31- June 28	June 28- August 2	August 2- Sept. 3	Sept. 3- Oct. 3	Oct. 3- Nov. 5	
1	22	20	26	14	15	22	20
2	9	7	13	NR	8	9	9
3	6	5	5	4	4	6	5
4	5	5	5	4	4	6	5
5	9	10	10	7	13	10	10
6	6	5	5	4	5	6	5
7	4	4	5	4	5	5	5
8	8	7	7	5	6	8	7
9	9	6	8	5	4	7	7
10	57	25	75	30	18	46	42
11	5	5	5	4	4	5	5
12	6	7	5	5	5	7	6
13	6	5	5	5	6	7	6
14	5	5	4	4	5	6	5
15	6	5	5	4	5	5	5
16	7	7	7	5	6	7	7
17	NR	8	9	6	10	10	9
18**	5	6	5	4	5	5	5
19	5	5	4	4	5	5	5
20	5	6	5	4	6	6	5
23	7	7	9	6	7	7	7
24	8	6	7	5	9	10	8
25	NR	6	6	5	5	7	6
26**	NR	5	4	4	6	5	5
27**	NR	5	6	4	6	7	6
28	6	7	7	5	6	6	6
MEAN - SITES 1,5,8,10 12,16,17	18	12	20	10	10	16	

*ug/g, dry weight.
**control sites.

NR - no results, analysis not conducted.
Underlined values exceed ULN guideline.

Shaded data exceed highest background values.

ULN - Phytotoxicology Upper Limit of Normal guideline for copper in moss is 60 ppm.

Table: 22 Concentrations* of Zinc in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						
Moss Bag Site No.	May 2- May 31	May 31- June 28	June 28- August 2	August 2- Sept. 3	Sept. 3- Oct. 3	Oct. 3- Nov. 5	SITE MEAN
1	64	48	72	44	53	65	58
2	92	48	130	NR	64	110	89
3	47	32	46	44	52	68	48
4	44	33	51	36	45	58	45
5	79	62	76	55	62	99	72
6	190	170	130	120	200	160	162
7	76	44	74	47	58	66	61
8	63	38	70	51	52	78	59
9	65	36	61	41	42	70	53
10	260	100	360	84	130	250	197
11	58	31	51	39	36	33	41
12	48	37	52	38	44	42	44
13	52	37	50	37	39	41	43
14	49	38	53	38	37	59	46
15	74	37	59	40	43	42	49
16	62	45	64	52	56	77	59
17	NR	89	150	59	90	57	89
18**	52	61	66	44	37	52	52
19	70	44	59	43	43	53	52
20	120	100	170	54	455	496	233
23	63	43	67	45	75	81	62
24	110	120	140	66	130	77	107
25	NR	71	180	57	71	120	100
26**	NR	63	70	42	49	65	58
27**	NR	72	89	52	88	130	86
28	65	68	74	46	77	75	68
MEAN - SITES 1,5,8,10 12,16,17	96	60	121	55	70	95	

*ug/g, dry weight. NR - no results, analysis not conducted.

**control sites. Shaded data exceed highest background values.

ULN - Phytotoxicology Upper Limit of Normal guideline for zinc in moss is 800 ppm, see appendix.

Table: 23

Concentrations[*] of Aluminum in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						SITE MEAN
Moss Bag Site No.	May 2-May 31	May 31-June 28	June 28-August 2	August 2-Sept. 3	Sept. 3-Oct. 3	Oct. 3-Nov. 5	
1	790	910	1200	910	1100	990	**983**
2	710	730	900	NR	1200	760	**860**
3	710	770	700	950	970	670	**795**
4	600	800	870	880	970	670	**798**
5	800	790	1100	1100	1200	790	**963**
6	690	710	520	960	890	860	**772**
7	630	720	1000	860	1300	830	**890**
8	660	800	920	890	1100	720	**848**
9	770	680	860	880	900	560	**775**
10	870	720	1100	730	1100	830	**892**
11	670	780	850	910	930	710	**808**
12	780	770	920	770	1200	880	**887**
13	690	850	830	800	810	700	**780**
14	640	810	740	820	990	600	**767**
15	650	830	890	970	1000	790	**855**
16	610	780	730	1100	940	580	**790**
17	NR	960	1100	1000	1100	850	**1002**
18[**]	780	810	580	810	840	910	**788**
19	660	750	820	1100	920	920	**862**
20	770	600	960	970	1000	900	**867**
23	710	850	940	930	1400	1100	**988**
24	610	700	620	960	1200	1000	**848**
25	NR	800	680	1100	1300	740	**916**
26[**]	NR	720	800	1100	1100	1000	**944**
27[**]	NR	590	870	980	1400	700	**908**
28	640	650	720	740	1100	1200	**842**
MEAN - SITES 1,5,8,10 12,16,17	**752**	**819**	**1010**	**929**	**1106**	**806**	

[*] ug/g, dry weight.
[**] control sites.

NR - no results, analysis not conducted.

Table: 24 Concentrations[*] of Magnesium in Moss Bags Exposed Near American-Standard During Each of 6 Monthly Exposure Periods from May to November, 1991

	Monthly Exposure Periods						
Moss Bag Site No.	May 2-May 31	May 31-June 28	June 28-August 2	August 2-Sept. 3	Sept. 3-Oct. 3	Oct. 3-Nov. 5	SITE MEAN
1	1500	1300	1500	970	1200	1400	**1312**
2	1400	1000	1200	NR	1100	1300	**1200**
3	1300	900	1100	860	1100	1700	**1160**
4	1400	930	1100	830	960	1700	**1153**
5	1600	1100	1300	940	1300	1500	**1290**
6	1700	850	980	860	950	1200	**1090**
7	1300	900	1100	810	1100	1000	**1035**
8	1900	1100	1200	900	1200	2100	**1400**
9	1600	1200	1500	920	1100	1900	**1370**
10	1800	1400	2300	1300	1900	1500	**1700**
11	1700	960	1100	850	920	1000	**1088**
12	1600	1100	1300	1100	1200	1200	**1250**
13	2000	1200	1400	890	980	1300	**1295**
14	1500	870	1000	790	1000	1600	**1127**
15	1900	1300	1300	820	1200	1100	**1270**
16	2100	1700	1400	1100	1300	1800	**1567**
17	NR	2900	2900	1700	3100	1700	**2460**
18[**]	1900	2200	1900	800	1200	NR	**1600**
19	1700	1300	1000	890	1200	1100	**1198**
20	1700	2000	1500	1100	2000	1300	**1600**
23	1900	2300	2600	1600	2200	1600	**2033**
24	1200	2200	2000	960	1600	1100	**1510**
25	NR	1400	2000	1100	1200	1900	**1520**
26[**]	NR	1900	1100	1100	1700	1200	**1400**
27[**]	NR	1100	1200	880	1300	1900	**1276**
28	1200	2200	2100	1000	1400	1300	**1533**
MEAN - SITES 1,5,8,10 12,16,17	**1750**	**1514**	**1700**	**1144**	**1600**	**1600**	

[*] ug/g, dry weight.

[**] control sites.

NR - no results, analysis not conducted.

Shaded data exceed highest background values.

Table: 25 Contaminants Associated with Emissions from American-Standard

Degree of Contamination	Contaminant
Definite Contaminant[1]	Boron Copper Fluoride Nickel
Marginal Contaminant[2]	Barium Sodium Titanium
Not a Contaminant[3]	Aluminum Magnesium Zinc

[1] Mean of 7 closest sites more than twice the highest concentration of the control sites.

[2] Mean of 7 closest sites less than twice the highest concentration of the control sites.

[3] Mean of 7 closest sites less than the highest concentration of the control sites.

APPENDIX

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.